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Effect of Salinity on Growth and Chlorophyll Response of Scotch Bonnet Pepper (*Capsicum chinense* L.) Planted in Sandy-Loamy Soil in Akure, Ondo State, Nigeria.

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ABSTRACT: Soil salinity is becoming more significant in agriculture because it stresses agricultural plants. Hence, the objective of this study is to investigate the effect of salinity on the growth response of Scotch bonnet pepper (*Capsicum chinense* L.) planted in Sandy-loamy soil in Akure, Ondo State, Nigeria. The plant height, leaf area, number of leaves, production of chlorophyll measured at different concentrations of sodium chloride (0g, 6.4g, 12.8g and 19.2g of ds/m of NaCl) treatment using standard methods. Results from the study showed that plant height increased progressively in the control plants throughout the data collection period. The highest height was at the control plant in the 9th week after contamination (WAC) with a height of 30.6 ± 0.61c. This was higher significantly ((P > 0.05) when compared to the other treatments which were 13.86 ± 1.62, 13.70 ± 0.11, 10.09 ± 0.11 respectively. Number of leaves was also higher in the control when compared with the treatment. Also, a steady increase was observed throughout the duration of the study in the number of leaves whilst in the other treatments, there was observed decrease in number of leaves from 5th to 9th WAC. Leaf area was significantly higher at control than other treatments. Increasing salinity led to a significant decrease in chlorophyll production. The control plants had the highest chlorophyll production, with total chlorophyll being 41.28 µm. On the other hand, the plants treated with 19.22 NaCl ds/m had the least chlorophyll production; with total chlorophyll a being 21.12 µm. Results from this study suggest that high salinity levels can negatively affect the growth of Scotch bonnet pepper.

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Salt is a naturally occurring element in soil that influences plant development and vigor (van Breusegem and Dat, 2006). The word "soil salinity" refers to the salt content in soil (Vaidyanathan *et al*., 2003). A saline soil is one that has a high concentration of soluble salts such as Na^+, K^+, Ca^{2+}, Mg^{2+}, and anions such as Cl^-, NO^{3-}, CO_3^{2-}, SO_4^{2-}. A soil with electrical conductivity (EC) of 4 dS m^{-1} or above is said to be saline (Verma and Mishra, 2005). Soil salinity is becoming more important in agriculture since it stresses agricultural plants. High salt levels in the soil have been noted to impede agricultural productivity (Rasel *et al*. 2013). This is due majorly to altered water relations resulting from significant salt deposition in intercellular spaces (Zhang *et al*. 2006). Soil salinity is influenced by a variety of variables that influence the quantity and composition of salts in soils, including irrigation water quality, fertilizers used, irrigation regimen and system type, and so on (Jaleel *et al*., 2007). The salinization of formerly fresh rivers, which results in reduction in the quality of water for irrigation, is the most major off-site effect of dry land salinity, with substantial economic, social, and environmental ramifications for both rural and urban residents (Esfandiari *et al*., 2007). Agriculture is greatly influenced by salinity; this is so because with high concentration of salts in the soil, most crops are vulnerable to salinity (Mahmuduzzaman *et al*. 2014). This research examines how soil salinity impacts Scotch bonnet (*Capsicum chinense*). It is a valuable

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commercial crop farmed for local use in Nigeria, with a high economic value on the Nigerian agricultural market (Benson and Olufunke, 2011). It contains vitamins A, C, and B6 and helps to protect the body from illness and prevent health issues (Martnez *et al*., 2005). Hence, the objective of this study was to investigate the effect of salinity on growth and chlorophyll response of scotch bonnet pepper (*Capsicum Chinense* L.) planted in sandy-loamy soil in Akure, Ondo State, Nigeria.

MATERIALS AND METHODS

Collection of plant materials: Seeds of Scotch bonnet pepper (*Capsicum chinense* L.) were collected from Agricultural Development Project, Akure, Ondo State, Nigeria. Sandy-loamy soil was used for this study. The soil was collected from a relatively undisturbed expanse of land within the Federal University of Technology, Akure. They were thoroughly mixed together and transferred to perforated plastic pots in the screen house.

Experimental setup: A screen house experiment was set up to house the pots. This was necessary to protect the plants from rainfall contaminations and to avoid being destroyed by rodents as the plants develop. Seeds of Scotch bonnet pepper (*Capsicum chinense* L.) were sown into perforated plastic pots (30 cm diameter and 33 cm depth) filled with 5 kg of topsoil. The seedlings were allowed to establish for a week before the commencement of treatment. The plants were treated with 250ml of 0 (control), 6.4, 12.8 and 19.2 ds/m salt solution. The whole experiment was replicated five times and completely randomized.

Preparation of salt solutions: A salt solution was made using Munns' (2002) methodology. 1 litre of distilled water was used to dissolve equimolar concentrations of nutritional salts to create stock solution. Each stock solution was combined with about 150 ml to make 120 litres, which was then used to water the plants to provide them enough nutrients to flourish. To prepare a solution of sodium chloride (NaCl) salt at concentrations of 6.4, 12.8, and 19.2 ds/m, pure NaCl salts were obtained from the research laboratory of the Department of Biology, Federal University of Technology, Akure, Nigeria. The salt was diluted with water gradually until the desired concentrations were achieved using a conductivity metre.

Salt treatment application: After 8 days of seedling establishment, seedlings were irrigated with 250ml of NaCl salts solutions every three days while distilled water (control) was used to irrigate the seedlings every other day.

Determination of growth parameters: After 2 weeks of salinity treatment, the following morphological growth parameters were determined weekly; Plant height, number of leaves, leaf length, leaf breath which was used to calculate leaf area.

Chlorophyll Extraction: Chlorophyll was determined following the method of Rajput and Patil, 2007. 1g of fresh leaf was grounded in 20ml of 80% (%) acetone using a mortar and pestle and then centrifuged at 5000rpm. The optical density of the supernatant was read at 645λ and 663λ using a linear readout spectrophotometer. Chlorophyll a, b and the total chlorophyll were determined using the stated formula.

$$Chlorophyll\ a = \frac{12.7(A663) - 2.69(A645) x\ V}{1000}\ x\ W \quad . (1)$$

$$Chlorophyll\ b = \frac{22.9(A645) - 4.68(A663) x\ V}{1000}\ x\ W \quad . (2)$$

$$Total\ Chlorophyll = \frac{20.2(A645) + 8.02(A663) x\ V}{1000}\ x\ W$$
(3)

Where, A = Absorbance at specific wavelengths; V = Final volume of chlorophyll extract in 80% acetone; W = Fresh weight of tissue extracted.

Statistical analysis: The data obtained was statistically analyzed using SSPS (version 22, 2017). A one way Analysis of Variance (ANOVA) was carried out and the means separated using Duncan Post Hoc.

RESULTS AND DISCUSION

The results of the growth response of *Scotch bonnet pepper (Capsicum chinense L.)* to increasing levels of salinity are presented in tables 1, 2 and 3 below. There was progressive increase in the plant height in the control plants from the beginning of data collection to the end. The highest height of 30.6cm in the control plants at the 9th week after contamination (WAC). This trend was also observed in plants treated with 6.4g and 12.8g of ds/m of NaCl with plant height of 7.88cm to 13.86cm and 7.68cm to 13.70cm respectively across the weeks data was collected. The number of leaves of *Scotch bonnet pepper (Capsicum chinense L.)* at different concentrations of sodium chloride (NaCl) treatment is also included in Table 2. In the first 3 WAC, number of leaves was highest in the plants treated with 19.2 ds/m of NaCl (4.0 and 5.4) when compared to all other treatments. There was a reversal of this trend from the 4 WAC with control plants having highest number of leaves till the 9 WAC (7cm to 14cm). Also, there was a continuous increase of the number of leaves in the control plants from 2 WAC to

9 WAC as against the other treatments where there was a continuous decrease in number of healthy leaves from 5 WAC through 9 WAC. Results of the leaf area are presented in table 3. Similar to the number of leaves, the control had a continuous increasing leaf area from week 4 WAC to 9 WAC. At the 9th WAC, the least leaf area was at the plants treated with 12.8g ds/m of NaCl (5.48) while the highest was at the control plants (115.92). In the other treatments, an initial increase in leaf area was observed. This increase started steadily decreasing in the 6th WAC in plants treated with 6.4g and 19.2g ds/m of NaCl and at the 5th WAC at 12.8g ds/m of NaCl treated plants. The results showed a relationship between salinity stress and pepper growth parameters such as leaf number and leaf area. These findings are in agreement with the results which have been reported for pepper (Karimi *et al.,* 2014). In an earlier investigation, the impediment of growth in pepper plants exposed to intense salinity was linked to a decline in carbon assimilation, primarily stemming from stomatal limitation and/or metabolic dysfunction (Hajiboland *et al.,* 2014). Additionally, the diminished growth of plants in saline environments has been ascribed to the direct hindrance of both cell division and expansion, as documented by Zhu (2001) and Munns (2002).

Table 1: Result of plant height of Scotch bonnet pepper in responses to salinity treatment

Treatment	**2 WAC Cm**	**3 WAC cm**	**4WAC cm**	**5 WAC cm**	**6 WAC cm**	**7 WAC cm**	**8 WAC cm**	**9 WAC cm**
Control	7.64 ± 1.06a	8.1 ± 1.27a	12.34 ± 1.30c	15.10 ± 1.77d	28.4 ± 2.41d	28.4 ± 2.41d	29.2 ± 0.21c	30.6 ± 0.61c
6.4g ds/m of NaCl	7.88 ± 1.43a	9.60 ± 2.07b	9.72 ± 1.56a	10.8 ± 2.25a	10.8 ± 2.25a	11.1 ± 1.05a	13.22 ± 0.05b	13.86 ± 1.62b
12.8 ds/m of NaCl	7.68 ± 0.83a	10.60 ± 2.79c	12.14 ± 3.38c	12.28 ± 3.31b	13.80 ± 0.23c	13.80 ± 0.23c	13.70 ± 0.11b	13.70 ± 0.11b
19.2 ds/m of NaCl	8.28 ± 0.63b	9.80 ± 1.84b	10.40 ± 2.05b	14.50 ± 1.86c	12.22 ± 1.12b	12.22 ± 1.12b	11.02 ± 0.14a	10.09 ± 0.11a

Values followed by same letter in the columns are not significantly different (P < 0.05) using Duncan's Post Hoc.

Table 2: Results of number of leaves of Scotch bonnet pepper in responses to salinity treatment

Treatment	**2 WAC**	**3 WAC**	**4 WAC**	**5 WAC**	**6 WAC**	**7 WAC**	**8 WAC**	**9 WAC**
Control	3.80 ± 0.45a	4.4 ± 0.55a	7.00 ± 0.70c	8.8 ± 1.30c	10.60 ± 1.95c	12.0 ± 1.07c	13.4 ± 2.97c	14.0 ± 0.47c
6.4g ds/m of NaCl	3.80 ± 0.45a	5.4 ± 0.55c	6.4 ± 1.52b	5.8 ± 0.45a	4.8 ± 0.45b	4.40 ± 0.24b	4.31 ± 0.14b	4.19 ± 0.10b
12.8 ds/m of NaCl	3.60 ± 0.55b	5.2 ± 0.84b	5.80 ± 1.30a	5.2 ± 0.84a	4.60 ± 1.67b	4.10 ± 1.00b	4.00 ± 0.87b	3.99 ± 0.90a
19.2 ds/m of NaCl	4.00 ± 0.00c	5.4 ± 0.89c	5.60 ± 0.89a	6.6 ± 1.67b	3.80 ± 1.10a	3.20 ± 0.90a	3.12 ± 0.60a	3.10 ± 0.60a

Values followed by same letter in the columns are not significantly different (P < 0.05) using Duncan's Post Hoc.

Table 3: Result of leaf area of Scotch bonnet pepper in responses to salinity treatment

Treatment	**4 WAC**	**5 WAC**	**6 WAC**	**7 WAC**	**8 WAC**	**9 WAC**
Control	14.68 ± 2.05d	22.94 ± 3.11c	37.33 ± 2.54d	79.38 ± 1.17d	107.33± 1.27d	115.92 ± 0.19d
6.4g ds/m of NaCl	9.65 ± 1.49c	10.53 ± 3.45b	18.69 ± 1.79c	12.19 ± 0.27c	9.29 ± 0.11c	8.05 ± 0.17c
12.8 ds/m of NaCl	8.01 ± 1.09b	8.60 ± 1.20a	7.45 ± 1.32a	7.31 ± 0.58a	5.78 ± 0.33a	5.48 ± 0.17a
19.2 ds/m of NaCl	6.12 ± 1.23a	10.98 ± 3.34b	12.50 ± 1.23b	10.74 ± 1.03b	7.75 ± 0.15b	7.17 ± 0.13b

Values followed by same letter in the columns are not significantly different (P < 0.05) using Duncan's Post Hoc.

Table 4: Chlorophyll accumulation of Scotch bonnet pepper under the influence of salinity

Treatment	**Chlorophyll a (mg/g)**	**Chlorophyll b (mg/g)**	**Total Chlorophyll (mg/g)**
Control	18.72±0.04d	22.56±0.02d	41.28±0.02d
6.4g ds/m of NaCl	12.78±0.01b	14.45±0.03c	27.23±0.01c
12.8 ds/m of NaCl	11.89±0.05b	12.50±0.04b	24.39±0.02b
19.2 ds/m of NaCl	10.57±0.07a	10.55±0.02a	21.12±0.01a

Values followed by same letter in the columns are not significantly different (P < 0.05) using Duncan's Post Hoc.

Results for chlorophyll production indicate that *Scotch bonnet pepper* was significantly affected by increasing salinity when compared with the control. Highest production was in the control with chlorophyll a being 18.72 µm, chlorophyll b 22.56 µm and total chlorophyll 41.28 µm. The least chlorophyll was at plants treated with 19.22 NaCl ds/m with chlorophyll a being 10.57 µm, chlorophyll b 10.55 µm and total chlorophyll 21.12 µm. Increasing salt concentration in the treatments led to decreasing chlorophyll production and this difference was significant at $p<0.05$. The results on chlorophyll content indicate that chlorophyll a, b and total chlorophyll reacted significantly to increasing salinity. Whilst the chlorophyll content was highest in control, the treatments showed a concentration dependent response as increasing salinity led to decreasing chlorophyll content. This is in conformity with salinity studies by Taibi *et al.* (2016) on *Phaseolus vulgaris*, Taffouo *et al.* (2010) and Ashrafuzzaman *et al.* (2000) on maize. The low values of photosynthetic apparatus in salt treated plants could be as a result of a low stomata conductance and protein contents, affecting Rubisco activity and electron transport (Evans, 2013). Also, Elsheery and Cao (2008) noted that chlorophyll reduction were as a result of either rapid breakdown or slow synthesis, which suggested the existence of a photoprotective mechanism via lowering light absorbance.

In plants, salt stress is a critical factor that severely affects plant growth and metabolism. Salinity stress involves complex and variable mechanisms that relate to different metabolic pathways of various organs. Growth has been considered as the result of different physiological mechanisms and its reduction after salt treatment has been widely described in different literature (Munns, 2002).

Conclusion: Salinity is a major problem across the globe. It has been shown to negatively affect the growth and yield of different plants. This study has been able to show that salinity negatively impacts the growth and performance of Scotch bonnet pepper (*Capsicum chinense*).

Declaration of Conflict of Interest: The author declares no conflict of interest.

Data Availability Statement: Data are available upon request from the corresponding author.

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